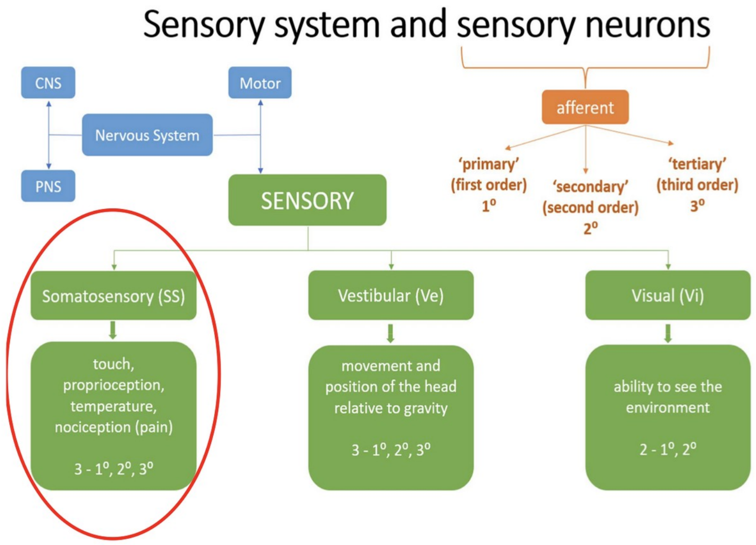
Neuromusculoskeletal System III

Objectives

- How somatosensory information enters the nervous system → receptors
- The neurons involved in the somatosensory system → primary 1 afferent (first order), secondary 2 (second order) and teriary 3 (third order) neurons
- Three subdivisions of the somatosensory system and their pathways
  - Dorsal column system
  - Anterolateral system (spinothalamic tract)
  - Trigeminal system


Sensory system and sensory neurons
CNS
Motor
Nervous System
PNS
SENSORY
afferent
'primary' (first order) 1°
'secondary' (second order) 2°
'tertiary' (third order) 3°
Somatosensory (SS)
touch, proprioception, temperature, nociception (pain)
3 - 1°, 2°, 3°
Vestibular (Ve)
movement and position of the head relative to gravity
3 - 1°, 2°, 3°
Visual (Vi)
ability to see the environment
2 - 1°, 2°

Three neuron pathways in somatosensory systems / tracts

Primary neuron

- Begins in the PNS which includes peripheral and spinal nerves / cranial.
- Cell body in sensory ganglion (DRG for spinal or trigeminal ganglion for cranial)
- Projects to spinal cord or brainstem where it synapses with the secondary.

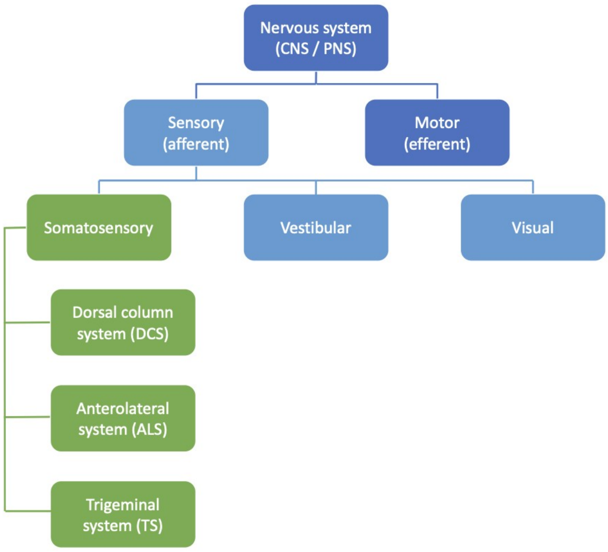
Secondary neuron

- From spinal cord or brainstem
- Cell body in spinal cord or brainstem
- Axon of second order cross the midline and projects to the thalamus.

Tertiary neuron

- From the thalamus
- Cell body in thalamus (primary relay station for sensory information)
- Projects to cortex of somatosensory area in cerebrum where it is processed and interpreted.

Somatosensory pathways / tracts



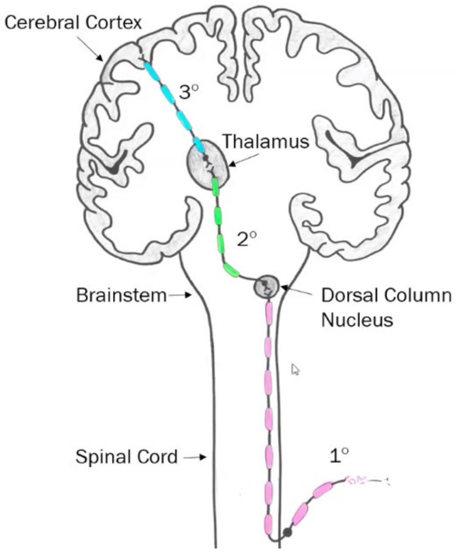
Dorsal column system (DCS)

Structure –

- Receptors in skin, muscle and joints of limbs and trunk
- Modalities: touch, proprioception
- PNS: peripheral nerves in the limbs and trunk to spinal cord
- CNS: pathway travels through multiple substructures of the CNS:
  - Spinal cord → brainstem → thalamus → cerebral cortex (grey matter) (somatosensory area)

Function –

- To deliver somatosensory information from the periphery (limbs and trunk) to the contralateral cerebral cortex for conscious awareness of somatosensory stimuli specifically touch and proprioception.



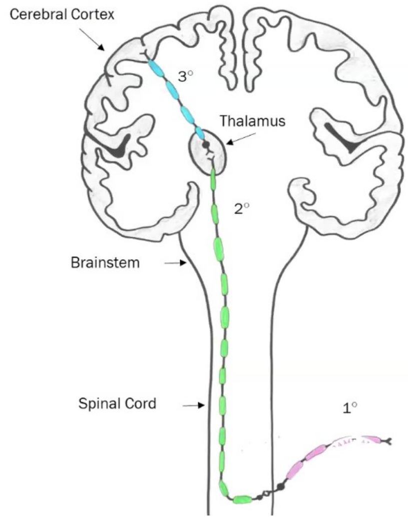
Anterolateral system / spinothalamic tract

Structure –

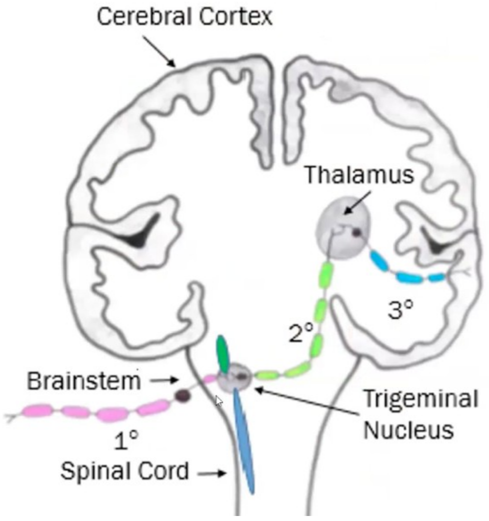
- Receptors in skin, muscles and joints of limbs and trunk
- Modalities: touch, temperature and nociception (doesn’t tell you where) exactly where I touched it comes from the other tract.
- PNS: peripheral nerves in the limbs and trunk → spinal cord
- CNS: Pathway travels through multiple substructures of the CNS
    - Spinal cord → brainstem → thalamus → cerebral cortex

Functions –

- To deliver somatosensory information from the periphery (limbs and trunk) to the contralateral cerebral cortex for conscious awareness of somatosensory stimuli specifically touch, temperature and nociception.



Trigeminal System



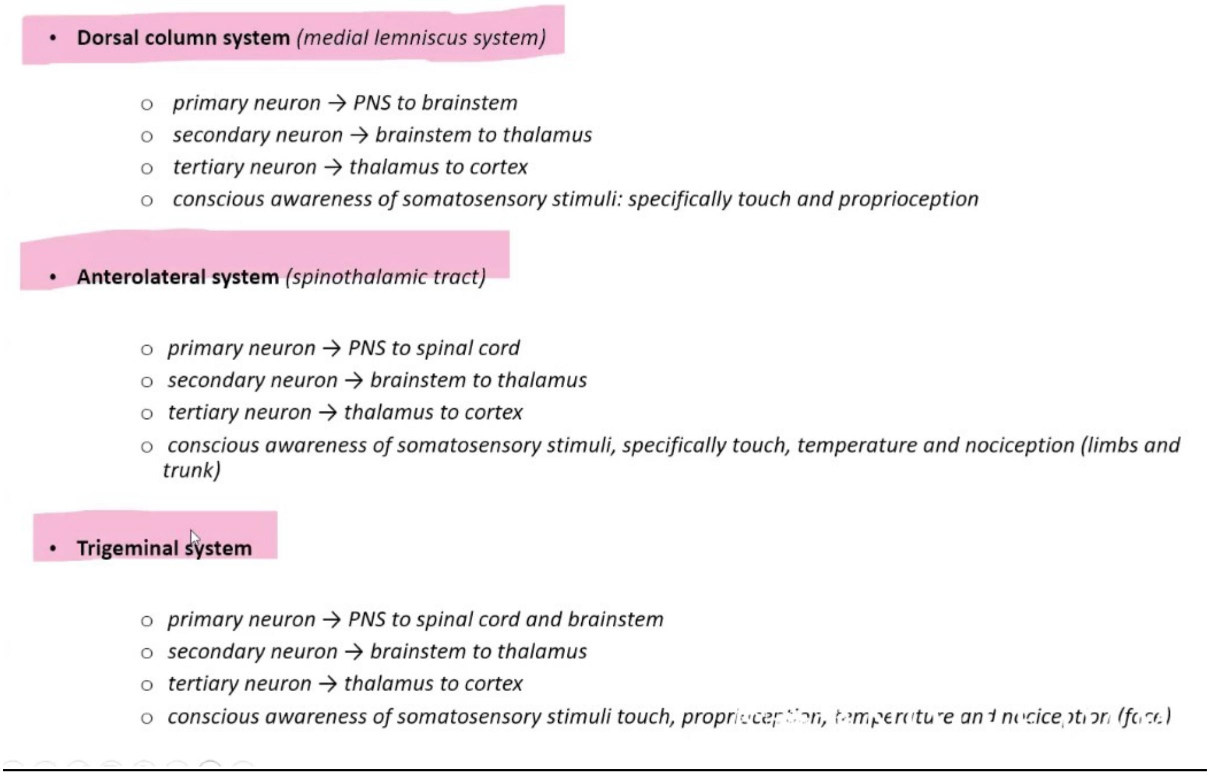
Structure –

- Receptors: skin, muscle and joints of face
- Modalities: touch, proprioception, temperature and nociception
- PNS: peripheral nerve in the face to spinal nerves and cranial nerves
- CNS: pathway travels through multiple substructures of the CNS
    - Brainstem and spinal cord → thalamus → cerebral cortex
    - Trigeminal nerve → trigeminal ganglion → brain stem → thalamus → cortex.

Functions –

- To deliver somatosensory information from the periphery (face) to the contralateral cerebral cortex for conscious awareness of somatosensory stimuli: touch, proprioception, temperature and nociception.

Ascending tracts – sensory tracts



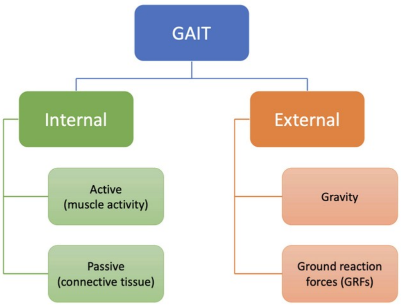
- **Dorsal column system** *(medial lemniscus system)*
    - *primary neuron → PNS to brainstem*
    - *secondary neuron → brainstem to thalamus*
    - *tertiary neuron → thalamus to cortex*
    - *conscious awareness of somatosensory stimuli: specifically touch and proprioception*
- **Anterolateral system** *(spinothalamic tract)*
    - *primary neuron → PNS to spinal cord*
    - *secondary neuron → brainstem to thalamus*
    - *tertiary neuron → thalamus to cortex*
    - *conscious awareness of somatosensory stimuli, specifically touch, temperature and nociception (limbs and trunk)*
- **Trigeminal system**
    - *primary neuron → PNS to spinal cord and brainstem*
    - *secondary neuron → brainstem to thalamus*
    - *tertiary neuron → thalamus to cortex*
    - *conscious awareness of somatosensory stimuli touch, proprioception, temperature and nociception (face)*

Gait III

Objectives

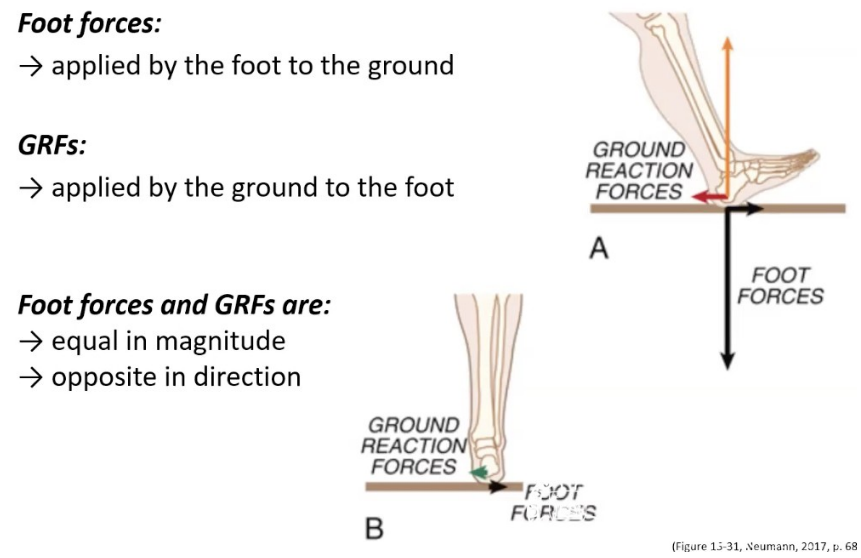
- Define foot forces and ground reaction forces (GRFs)
- Outline vertical and anterior-posterior GRFs during normal gait
- Explain the impact of normal GRFs on movement of the lower limb during gait.
- Explain the impact of abnormal GRFs on movement of the lower during gait in a clinical case affected weakness from neurological condition.

Forces: gait



Passive – These tissues store and release energy, contribute to joint stability and assist in the efficient transfer of forces.

Foot forces and GRFs



Foot forces:

→ applied by the foot to the ground

GRFs:

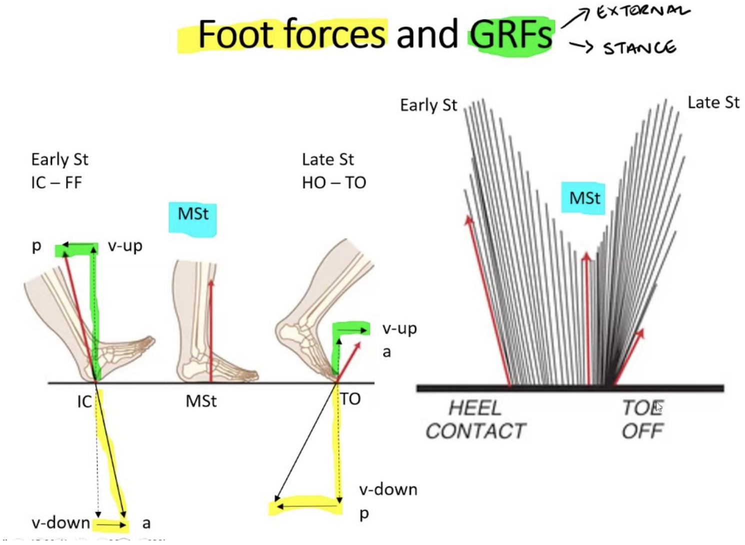
→ applied by the ground to the foot

Foot forces and GRFs are:

→ equal in magnitude
→ opposite in direction

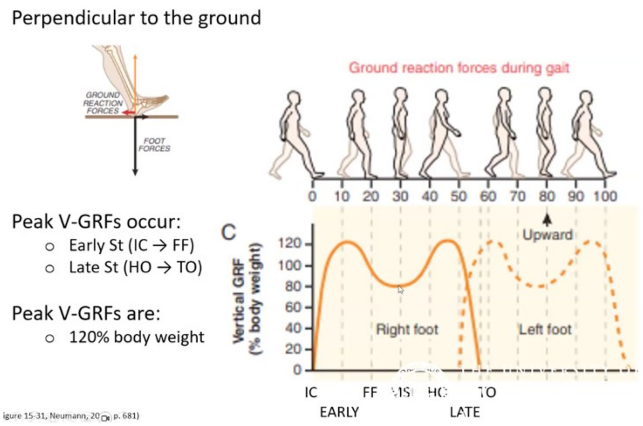
(Figure 15-31, Neumann, 2017, p. 68

Vertical plane (vertical upwards / GRF & vertical downwards / foot force)
Antero-posterior plane
Medio-lateral plane



Foot forces and GRFs → EXTERNAL → STANCE

Vertical GRFs



Perpendicular to the ground

Peak V-GRFs occur:

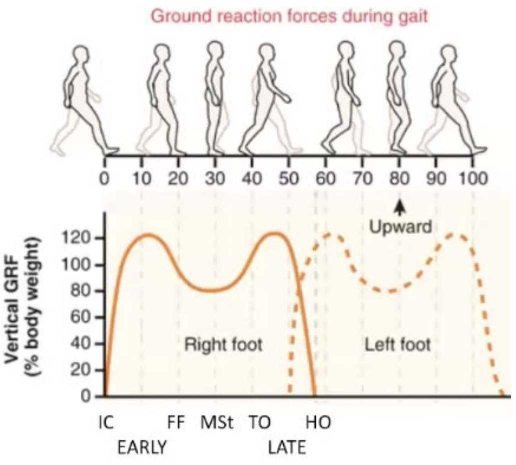
- Early St (IC → FF)
- Late St (HO → TO)

Peak V-GRFs are:

- 120% body weight

igure 15-31, Neumann, 20 p. 681)

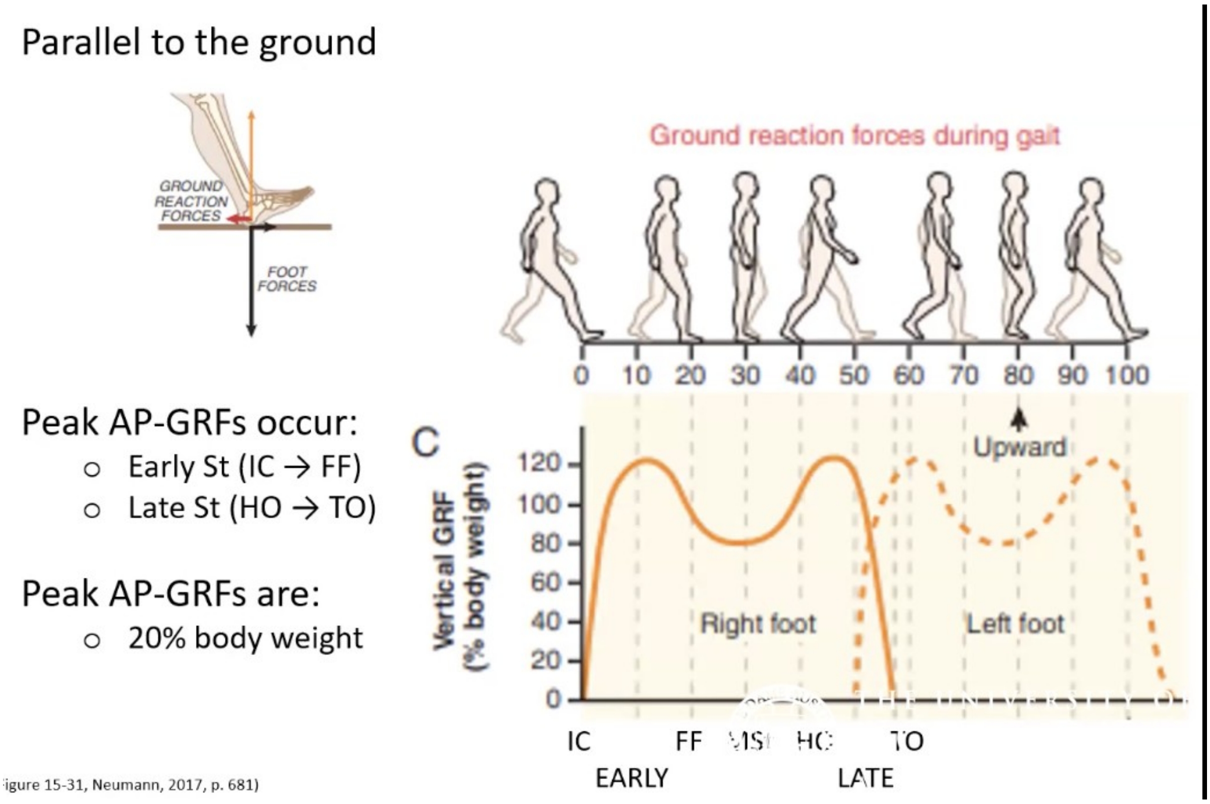
- In the middle of stance – although the foot is on the ground, the vertical ground reaction forces are slightly less than body weight (slightly less than 100%) – foot loaded – extensor forces at the hip and knee generated early in stance – the is the timepoint where we move forward over the grounded foot – we are not landing onto the ground or pushing off the ground.



- The peaks in vertical ground reaction forces help with deceleration in early stance as the body moves in a downward loading response from IC to FF. The peak in vertical ground reaction forces during late stance helps with acceleration of the body as we push off the ground to move the limb upwards into swing.

Anterior-posterior GRFs

Second biggest GRFs



Parallel to the ground

GROUND REACTION FORCES
FOOT FORCES

Peak AP-GRFs occur:
- Early St (IC → FF)
- Late St (HO → TO)

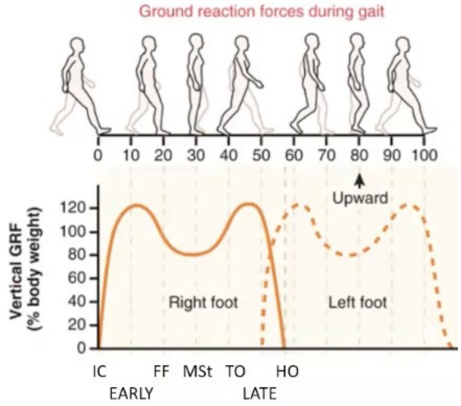
Peak AP-GRFs are:
- 20% body weight

Ground reaction forces during gait
0
10
20
30
40
50
60
70
80
90
100
C
Upward
Vertical GRF (% body weight)
120
100
80
60
40
20
0
Right foot
Left foot
IC
FF
MSt
HO
TO
EARLY
LATE

igure 15-31, Neumann, 2017, p. 681)

- From IC to FF – the foot is applying an anterior, positive force the ground. The ground therefore applies a posterior, negative force to the foot.

- From HO to TO, the foot is applying a posterior, negative force to the ground to push off. The ground therefore applies an anterior, positive force to the foot.

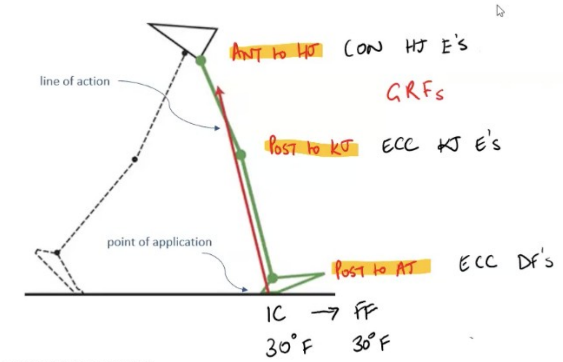


- Vertical GRFs are the largest of the 3 types of GRFs – peak vertical GRFs are normally equivalent to 120% of our body weight. AP GRFs are much smaller, only equivalent normally to a maximum of 20% of our body weight, and medial lateral even smaller at 5%.

- In the middle of stance – the anterior-posterior ground reaction forces are minimal – this is the timepoint where we move forward over the grounded foot – we are not landing onto the ground or pushing off the ground.

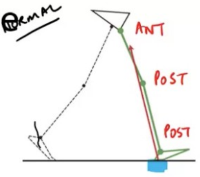
Early Stance

"GRFs under the foot generate an external torque on the joint of the lower extremities" p.683 (Neumann)

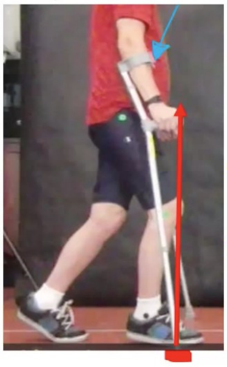


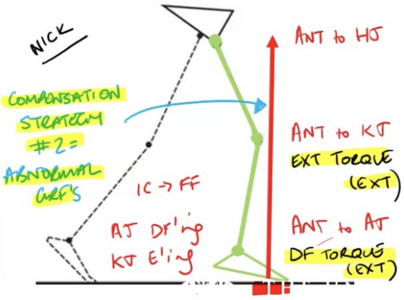
gure 15-34, Neumann, 2017, p. 681)

Nick - Early Stance



COMPENSATION STRATEGY
Ⓡ IC #1 = ECK'S
FOOT FORCES
GRF's

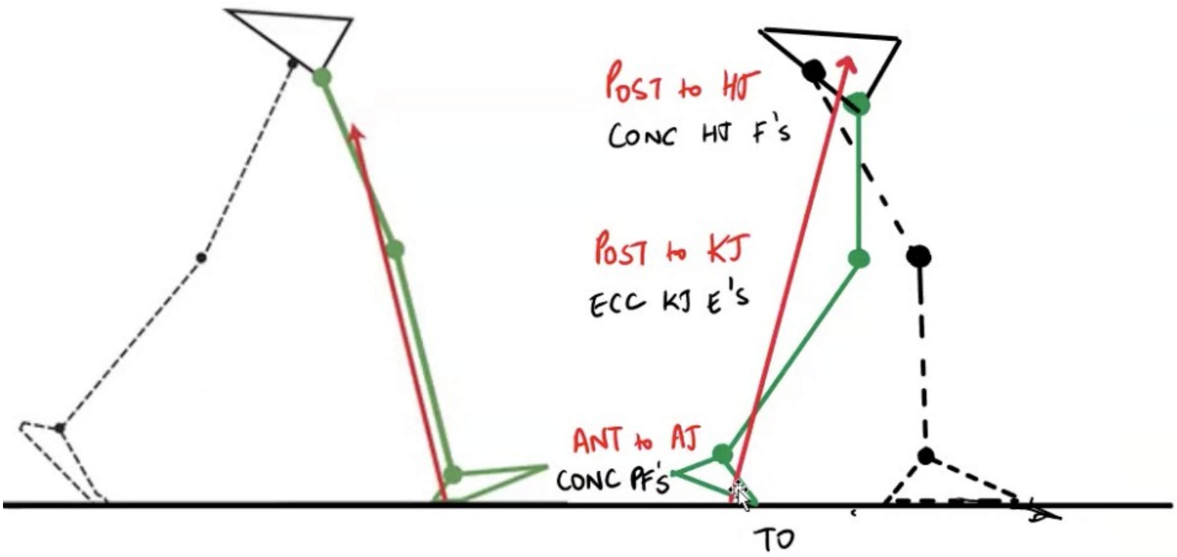




Late Stance

HO → TO

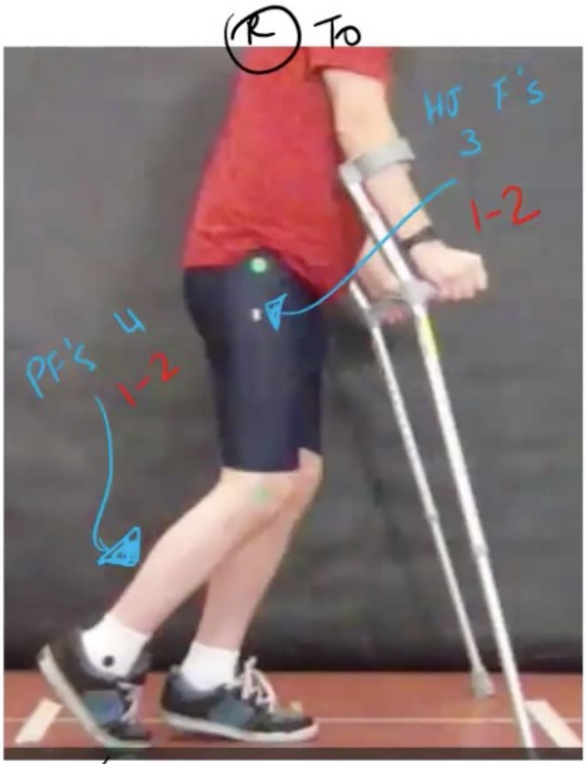
SSC → HIP F's #2
→ ANKLE PF's #1



HO →MSW ~~MUSCLE ACTIVITY~~

Nick - Late Stance

(R) TO



↙ * SMALL MAGNITUDE

(R) MSW